Within and between year phenology of calling Spotted Crakes *Porzana porzana* in Denmark

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Abstract

Analysis of data relating to calling Spotted Crakes *Porzana porzana*, input to the Danish Citizen Science portal DOFbasen, suggested that on controlling for observer effort, national numbers reported annually have remained reasonably stable during 1981–2013, but with large influxes in a very few years, mostly due to large arrivals late in the season in June/July. Standard annual mapping of calling birds at Vejlerne, numerically the most important breeding area for the species in Denmark, correlated well with annual national indices over the same period of years. Calling birds mapped at Vejlerne and those reported to DOFbasen both showed a consistent bimodal pattern, with peaks in April/May and June/July, although the relative size of the second peak in particular varied between years. We speculate on the causes of these two peaks in calling activity which both potentially relate to birds defending territories and intending to breed. The often large late influx, and the occupancy of different territories during the second peak compared to the first, suggested the second wave of birds were different individuals to those recorded earlier in the season. Radio telemetry showed early breeding birds to be still present but silent during the second peak in calling activity, suggesting a new wave of late arriving birds in July (possibly from areas to the south or elsewhere where they may previously have attempted to breed) which potentially also attempt to breed in Denmark. We recommend continuing radio telemetry studies to confirm whether the same individuals call in both periods, supplemented by high quality sound recordings to differentiate individuals on the basis of their calls and assess the existence of any recognisable

dialects across Europe. Stable isotope analysis of feathers grown outside the breeding areas would also help to provide a better understanding of the breeding status, origins and relative abundance of calling birds in these two waves.

Key words: annual abundance, Lille Vildmose, migration phenology, Vejlerne.

Despite being listed on Annex I of the European Birds Directive as a species of high conservation concern, very little is known about the abundance, distribution, habits and habitat requirements of the Spotted Crake *Porzana porzana* in Europe during the breeding period. Two major reasons for the lack of knowledge are: (i) the species' use of extensive wetland habitats which are difficult to access, and (ii) its generally highly secretive and silent nature, excepting the remarkable whiplash advertisement call given largely at night during the breeding season, mostly by males, but also by females which may duet with males (Cramp & Simmons 1980). Population estimates rely almost entirely on reports of calling birds, yet we still understand very little about how calling relates to breeding activity and abundance, not least because the calling period can extend between early April and early September (Stroud *et al.* 2012), can vary in timing during the night (Bengston 1962; Mortensen 1972; Mallord 1999; Schäffer 1999; Mackenzie 2000) and birds do not call every night, with calling activity potentially influenced by prevailing weather conditions (Stroud *et al.* 2012; Fox *et al.* 2013).

The Spotted Crake was considered a widespread and common summer breeding species in Denmark in the 1800s (Winge 1906), but had begun to decline even by the early 1900s (Løppenthin 1967). By 1960, it was considered that 45–115 pairs bred across 18 sites in Denmark (Ferdinand 1980) and that 32–55 pairs were nesting in the country by 1978–1981 (Dybbro 1985). The most recent breeding bird atlas found 22–61 breeding pairs at 15 sites during the 1990s (Grell 1998) and regular monitoring during 1999–2008 located numbers ranging from just over 200 to fewer than 25 pairs present each year (Bruun & Christensen 2008). The criterion for Spotted Crake to attain favourable conservation status within Denmark is that the breeding population should be stable or increasing from a minimal level of 35 pairs (Søgaard *et al.* 2007). Hence it is important when assessing the national conservation status of the species to be able to know what calling birds represent and how their number may fluctuate from year to year.

In this analysis, we attempt to assess the annual fluctuations in summer abundance of the species in Denmark based upon annual reporting of Spotted Crakes to the DOFbasen Citizen Science portal, supplemented by detailed mapping of calling birds at the single most important breeding concentration of the species, at Vejlerne in the northwest of the country, since 1978. Information about the timing and distribution of calling birds is used to interpret its phenology of migration and breeding status.

Methods

Annual numbers of reported Spotted Crake observations

We collated all reports of Spotted Crakes from the Danish Ornithological Society's (DOF) Citizen Science web portal "DOFbasen" (http://www.dofbasen.dk/), which amounted to 2,467 observations made between 8 May 1960 and 28 August 2013. Spotted Crake has been included in DOF's Rare and Threatened Species Programme since 1999 which encouraged all records to be entered into DOFbasen (Bruun & Christensen 2008). Total numbers of all bird observations entered into DOFbasen has increased steadily over the years, so we attempted to control the increase in observer effort and/or reporting rates by generating a calibrated assessment of annual relative abundance. To do so, we first truncated the data series to remove all years when the national numbers of Spotted Crakes reported (n) was less than 10 (effectively prior to but including 1981). We then adjusted for the reporting effort to DOFbasen associated with breeding birds, by dividing n by the annual number of reports of all breeding bird records (d) in that year, to give an index of relative abundance for Spotted Crakes (i):

$$i = n/d$$

Annual abundance of Spotted Crakes at Vejlerne

Reporting of observations may however be limited by the fact that similar numbers of observers visit only the same known sites for Spotted Crakes each year. To attempt to control for this effect, we also compared the national index with the annual standard monitoring census data generated at the most important site for the species in Denmark. Vejlerne (56°59'–57°07'N, 8°52'–9°08'E) in northwest Jutland is one of Denmark's outstanding freshwater wetlands and is a National Nature Reserve, a Special Protection Area and a Ramsar site, owned and managed by the Aage V. Jensen Foundation since 1993. The reserve comprises an embanked area of some 6,000 ha of grazed meadows, marshland, reedbeds and open water areas, that were until 1880 part of the Limfjord, now managed for the conservation of the high wetland biodiversity of the area. It has long been recognised as the most important area in Denmark for its breeding Spotted Crakes (Dybbro 1976; Grell 1998; Kjeldsen 2008) which are mainly found in the wet zones between meadows and reedbeds (Bruun & Christensen 2008). In recognition of its national and international importance, the breeding birds of the reserve have been monitored since 1978, although the individual records from this scheme are not entered into DOFbasen. The monitoring programme undertakes a regular assessment of breeding numbers present of nocturnally active Spotted Crakes, which includes regular night-time transects to count calling birds, following standardised routes and count techniques used from 1978 onwards. The presence of calling birds is mapped by determining angles to calling individuals from more than one observation position and plotted to determine occupancy of territories as the basis for estimating numbers of territory holders present in each year (Kjeldsen 2008). Given its importance

and the fact that the numbers recorded there are not regularly entered in DOFbasen, we consider the annual abundance of Spotted Crakes at Vejlerne as an independent estimate of annual fluctuations in abundance at this important site. No counts were made at Vejlerne in 2004.

Annual variation in patterns of reports of calling observations

Each DOFbasen entry consists of the number of individuals recorded, their behaviour and information about the nature of the observations. For the purposes of this analysis, we are most interested in calling birds because it is generally considered that these in some way constitute birds advertising their presence in relation to breeding (either territorial defence and/or mate attraction). To filter this dataset for birds only making advertisement calls, we retained all records: (i) for which any part of the behaviour was recorded as "calling", "staging and singing", "staging, only heard" or "territory defence", (ii) all records without behaviours where there was some indication in the comments or observation circumstances that showed the birds were heard, and (iii) all records made between 23.00–04.00 h for which there was no other information, assuming that these were of calling individuals. For each year, from 1998 to 2013 inclusive (years for which we considered there were sufficient data, where numbers of reports were > 50) we extracted all observations corresponding to these criteria and plotted them in 10-day periods from 1 January in each year as a percentage of the total observations of calling birds in that year to correct for annual variations in abundance.

Radio telemetry and mapping of calling individuals

In summer 2013, three males and one female (the latter paired to one of the males) were caught in the northern part of Lille Vildmose in north eastern Jutland (56°55'N, 10°11'E) using playback calls, mist nets, hand nets and walk-in traps (see Fox *et al.* 2013). Birds were fitted with 1.38 Biotrack Pip AG 392 VHF radios and tracked until the battery power was exhausted (see Fox *et al.* 2013 for full description). Positions at times through the day and night were determined by triangulation from more than one observation point on 18 dates between 31 May and 16 August 2013 (as presented in Fox *et al.* 2013). This method was used to determine the presence of the tagged (and potentially silent) birds in relation to the presence of calling birds which were monitored throughout Lille Vildmose on 16 nights between 16 April and 9 July (see Fox *et al.* 2013 for details).

Results

Annual number of Spotted Crake observations

The average annual number of Spotted Crakes reported to DOFbasen from 1982 to 2013 inclusive was 122 (ranging from 10 in 1985, up to 465 in 2003). When corrected for observer effort by dividing the number of Spotted Crakes reported by the number of reports of all breeding bird species, there was considerable annual variation in numbers (Fig. 1), but it can be seen that there has been no significant change in relative abundance over the time series

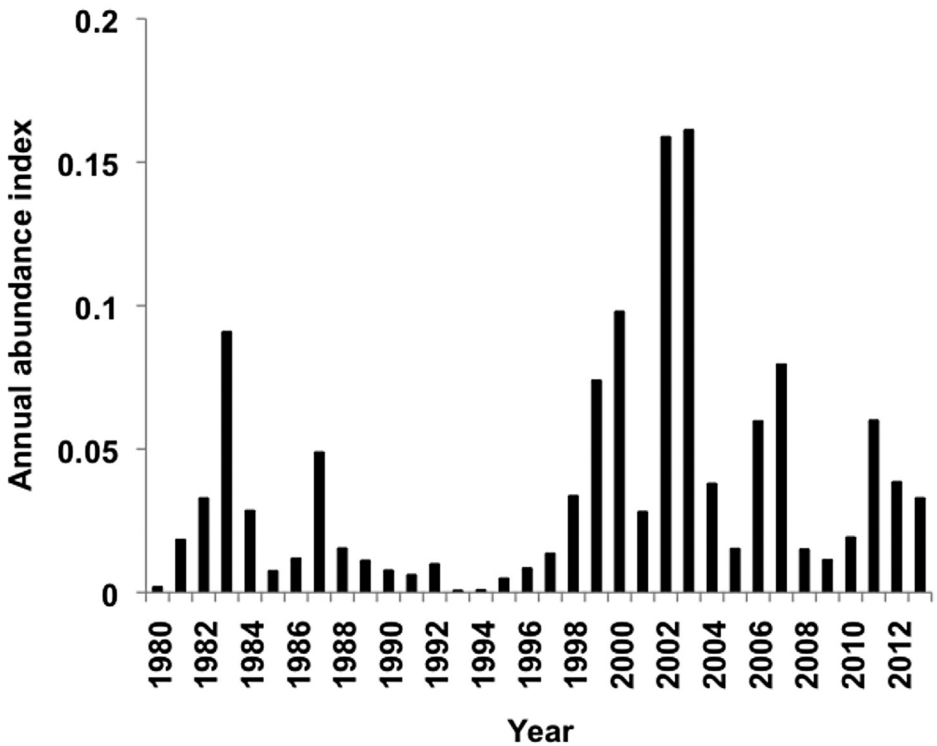

Figure 1. Annual index of the numbers of Spotted Crakes in Denmark reported to the Danish avian Citizen Science Portal DOFbasen during 1980–2013. The index adjusts for observer effort by dividing the total numbers of individual Spotted Crakes registered by the numbers of all breeding bird reports in each calendar year (*i.e.* as a measure of breeding bird reporting effort). Data from 1980 and 1981 are shown for completeness, but not included in the analysis because < 10 birds were reported in both years.

(y, $i = 0.0011y - 2.175$, $F_{1,32} = 2.52$, $r^2 = 0.07$, $P = 0.12$, n.s.), although there have been a series of years with exceptional numbers (1983, 1999, 2000, 2002, 2003 and 2007) when numbers exceeded 0.0733, double the mean index value. Interestingly, the annual indices for Corncrake *Crex crex* and Common Quail *Cortunix cortunix* (calculated in the same way, weighing reports for annual breeding records submitted to DOFbasen) were highly significantly correlated with Spotted Crake indices for the years 1980–2013 ($r^2_{32} = 0.77$, $P < 0.0001$ and $r^2_{32} = 0.34$, $P < 0.0001$, respectively). There was no correlation between annual breeding abundance in the UK (data from Stroud *et al.* 2012) and the Danish indices presented here (both data natural log transformed during 1980–2009; $r^2_{30} = 0.02$, $P = 0.51$, n.s.) to suggest major flyway level fluctuations in annual abundance affecting numbers in both countries.

Annual abundance of Spotted Crakes at Vejlerne

The annual abundance of calling Spotted Crakes mapped on territories at Vejlerne is shown in Fig. 2, where it can be seen that there were similar trends in annual abundance to those generated from DOFbasen reports, although with lower numbers since 2003. Numbers correlate well between the adjusted DOFbasen observations and annual numbers monitored at Vejlerne ($r^2_{33} = 0.60$, $P < 0.001$ for 1978–2013 inclusive), which suggests that in years with many reports from throughout Denmark, there were also many registrations of calling birds at Vejlerne.

Annual variation in reports of calling observations

The reports of calling birds throughout Denmark showed a conspicuous bimodal distribution through the summer (Fig. 3) as did the mapped calling birds recorded at Vejlerne during 1978–2003 (Fig. 4, although differences in the relative size of the two peaks were much less there) with a clear peak from mid–April to mid–May but another, even greater peak from the last week of June until the last week of July. This general pattern of song phenology masks considerable year to year variation however, although the bimodal pattern of song is relatively constant. In some years, there is an evident dominant early peak (as in 1998, 2005, 2006 and 2008, see Fig. 5); in other years the later peak is the dominant feature (as in 1999, 2000, 2002, 2003 and 2007, Fig. 5), whilst in yet other years, the two peaks are even and are very similar between years (2001, 2004, 2011 and 2012, Fig. 5). In two recent years, the spring arrival has been relatively delayed and the bimodal pattern dampened but still evident (2009 and 2013, Fig. 5). Interestingly, four of five years with conspicuously large proportions of calling birds in the June/July peak (1999, 2000, 2002 and 2003) were years of very high overall numbers of reports of calling birds. It would thus appear that in most years between 1998 and 2013, there was a mean of 50 (s.e ± 7.9, range = 11–111) reports of calling Spotted Crakes during April/May, but greater and more variable numbers (mean 91 ± 19.9, range 2–248) of calling birds in the second peak in June/July.

Do birds in the two peaks sing in the same areas?

Based on mapping of calling birds at Vejlerne, there was evidence from the major influx in 1983 that although some birds arrived and set up territories in April/May of that year (8 individuals), the major numbers (31) arrived in June/July and began calling in areas not previously occupied by calling birds (Christensen & Engelstoft 1984). In summer 1984, exceptional numbers occurred again, although the main arrival was in the first peak (44 territories) with fewer in the second (22, Rasmussen 1987). In 1986, when more normal numbers occurred, the first peak (23) again exceeded the second (9) and their distributions were again mutually exclusive (Danielsen 1989) and the same was the case in 1988 when 51 and 32 territories were mapped, with the birds in the second wave occupying different areas to the first (Petersen 1990). Similar patterns were reported in summer

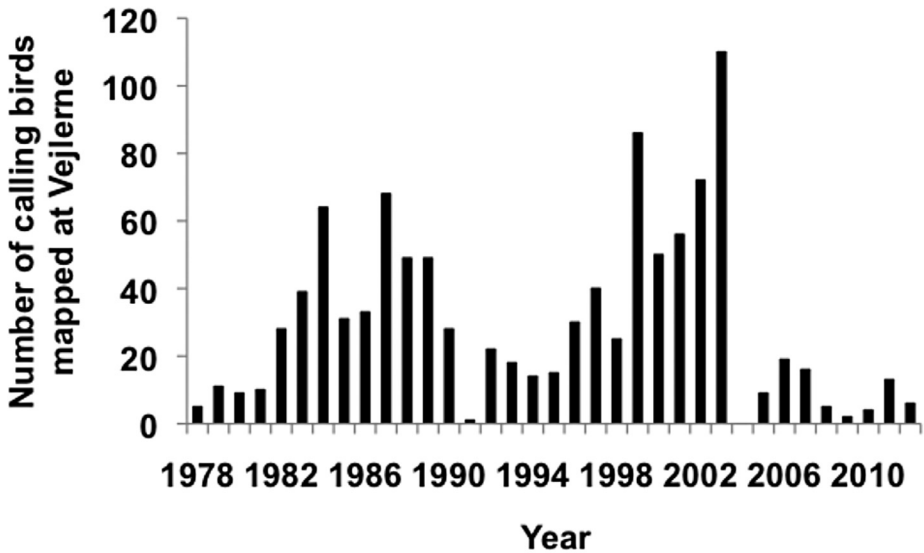

Figure 2. Estimated annual number of calling birds at Vejlerne, north Jutland during 1978–2012, based on mapping of birds' distribution, using the same census methods each year. Data from Kjeldsen (2008) and Nielsen & Kjeldsen (2013).

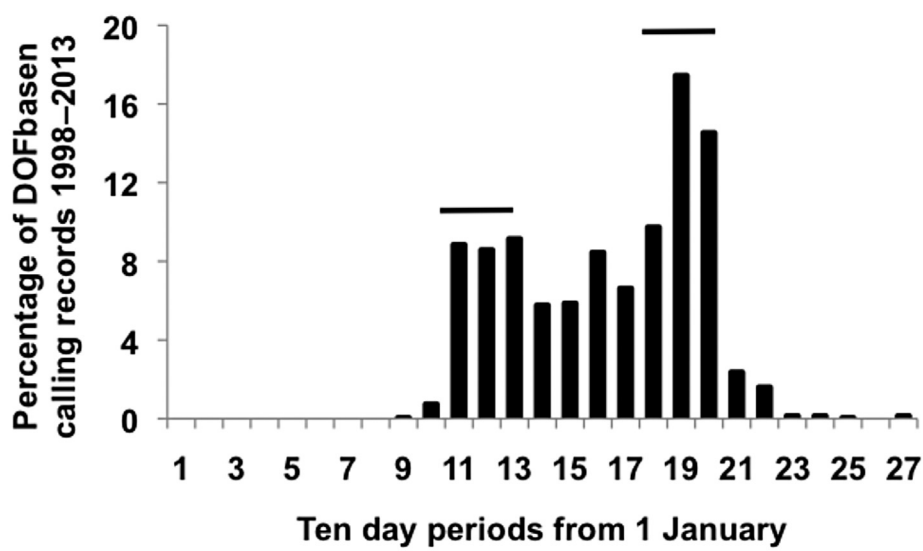

Figure 3. Frequency distribution of all calling Spotted Crakes reported to DOFbasen during the years 1998–2013 inclusive, in 10 day periods from 1 January. Horizontal lines above histogram columns indicate the two peaks in reporting of calling birds in April/May and June/July.

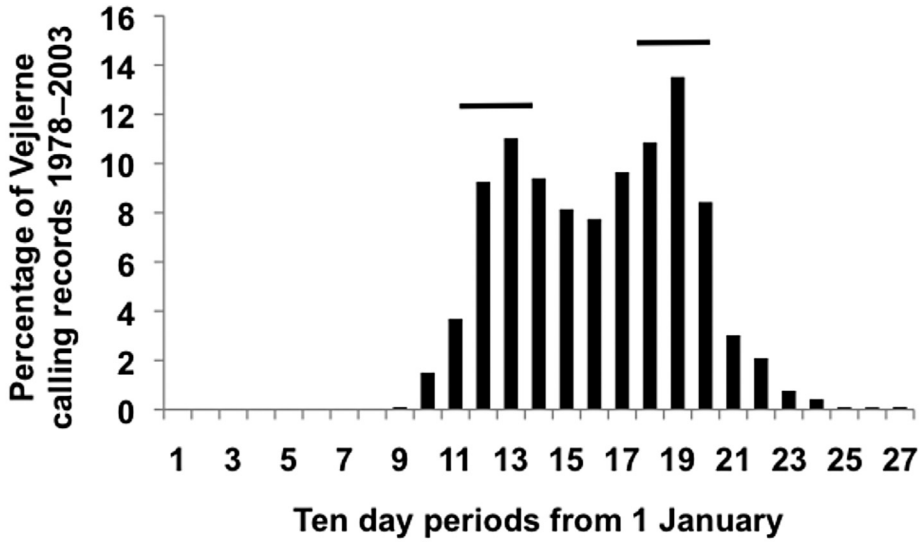

Figure 4. Frequency distribution of all calling Spotted Crakes mapped at Vejlerne during the years 1978–2003 inclusive, in 10 day periods starting 1 January. Horizontal lines above histogram columns indicate the two peaks in reporting of calling birds in April/May and June/July.

1989 and 1990 (Seidenfaden 1991; Petersen 1993). Based on intensive observations at Lille Vildmose in 2013 (reported in Fox *et al.* 2013), three territory-holding radio-tagged males were exclusively vocally active in the first peak, while "new" birds were heard in two other areas in the later peak, but in three other areas, birds were heard calling during both periods.

Are the birds calling in the two peaks the same individuals?

Tracking data from the three radio-tagged males and one female at Lille Vildmose during summer 2013 showed not only that all four birds arrived during the first peak, but that the males commenced calling in the first peak that year. All four tagged birds were present from the time they were caught in late May until the end of June (n = 1) and late July/early August (n = 3 included the male and female of the pair) when the transmitter batteries ran out (Fox *et al.* 2013). In one case, a nest was found, but the constant presence of these birds throughout the second peak when birds were calling elsewhere at Lille Vildmose suggest that the three tagged males remained on site to raise their young in the area at or near where they defended their territory, having ceased calling in late May. Their silent presence during the second peak confirms that these individuals are still present on their existing territories, but did not start to call as part of the second peak and also that they did not move to contribute to the second wave of calling on site or at wetlands elsewhere.

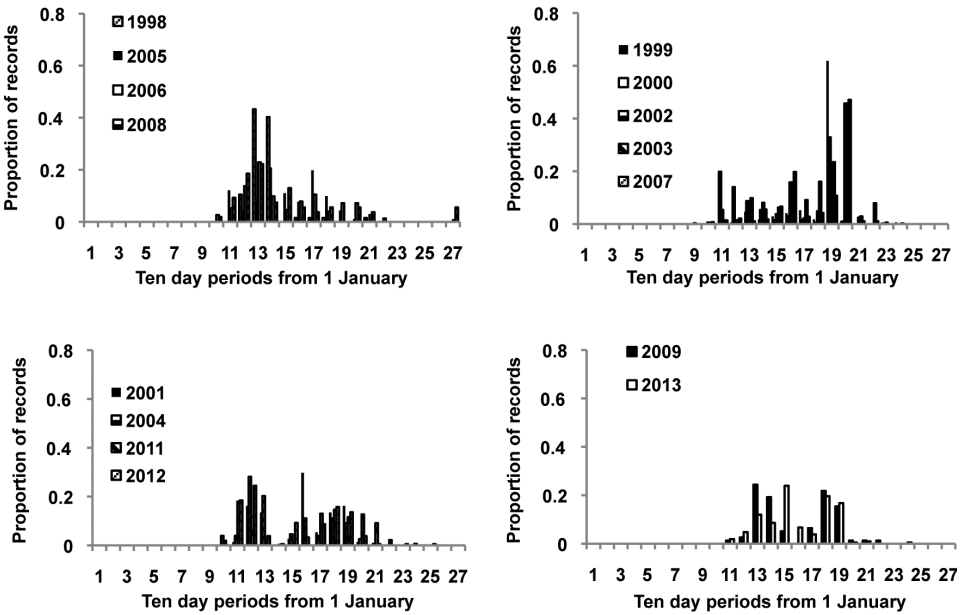

Figure 5. Annual frequency distribution of all records of calling Spotted Crakes reported to DOFbasen during the years 1998–2013 inclusive, broken down by 10 day periods starting 1 January as shown in Fig. 3. Years are aggregated by the nature of the frequency distributions – top left shows a dominant arrival peak in April/May, top right a dominant arrival peak in June/July, bottom left shows even bimodal peaks in both periods and bottom right shows a similar distribution but after a delayed arrival in spring.

Discussion

Controlling for observer effort, DOFbasen registrations suggest that despite wide fluctuations between years, the numbers of reported Spotted Crakes have remained reasonably stable during 1981–2013. The greatest source of inter-annual variation appears to arise from the periodic influx of birds as happened in large numbers in 1983, 1998, 1999, 2002 and 2003 and to a lesser extent in 1984, 1987 and 2000. Based on standard mapped distributions of calling birds since 1978 at the numerically most important site in Denmark, Vejlerne, the annual abundance there was highly correlated with the corrected national abundance and showed the same peaks in abundance in the same years. These results suggest that it may be extrinsic factors that affect the annual numbers in Denmark, or that macro-environmental factors (such as winter and spring precipitation and the subsequent effect on water tables) affect overall settlement of calling birds. Studies elsewhere in the range show that breeding birds abandon breeding areas when the habitat dries out and water level can affect the abundance of settling birds (for example in Poland; Schäffer 1999) and some earlier analyses showed correspondance between higher water levels at Vejlerne and numbers

of calling Spotted Crakes in individual management units (Kjeldsen 2008) although others did not (Clausen *et al.* 2006). Hence, the condition of wetlands in Denmark in spring does likely contribute to the numbers of Spotted Crakes in the first peak remaining and breeding successfully.

Temporal analysis showed that there was a conspicuous bimodal distribution in the abundance of calling Spotted Crakes through the summer with clear peaks during mid-April to mid-May and from late June to late July. Although this pattern was not evident from a similar analysis of British data of calling Spotted Crakes (see Fig. 13 in Stroud *et al.* 2012), those authors stated that there was a peak in activity from mid-April to mid-June "with peaks in early and late May". Song phenology in Denmark showed considerable year to year variation, which subjectively could be summarised into the four classes shown in Fig. 5, namely a dominant early peak, a dominant later peak or two similarly sized peaks, with a variant of the latter resulting from a late spring arrival, but retaining a bimodal distribution. What is perhaps most interesting is that the major influxes of 1983 (based on data from Vejlerne), 1999, 2000, 2002 and 2003 (DOFbasen elsewhere in Denmark) were all associated with exceptional numbers of calling birds reported in the second peak during July, whilst those of 1984 (Vejlerne) and 1998 (DOFbasen) were associated with an early peak in calling birds and those in 1987 (Vejlerne) were equally distributed between early and later peaks.

What do the two peaks in calling birds represent? There could be several explanations, of which the simplest two are that: (i) two groups of Spotted Crakes arrive sequentially in Denmark and begin to establish territories at different times, or (ii) after an initial period of arrival, pairing and reproduction, the same birds restart territorial advertisement once investment in the first brood is completed. The data presented here tend to suggest that the second of these hypotheses is not supported, firstly because the second peak can be numerically far superior to the earlier peak in numbers, which suggests more territory holders are present later in the season, although we cannot exclude the possibility that many birds establish territories, pair successfully and reproduce in both periods without detection. The radio-tracking results suggested birds may stop calling soon after attracting a mate. Furthermore, data from Vejlerne in several years and to some extent Lille Vildmose in 2013 suggest that birds that begin to call late on in the season occupy different areas to those occupied during the first peak in abundance. Without tracking more individuals, we cannot exclude the possibility that this is merely because the same birds shift in relation to habitat change (for example water table recession; Schäffer 1999; Fox *et al.* 2013) and so exploit two different areas within the same year to raise broods in ephemeral hydrological conditions as these change through the course of the summer. The limited radio-tagging of individuals at Lille Vildmose in 2013 suggest this was not the case – all three males fell silent soon after marking, but remained active in the same general areas throughout the period when they were likely involved in brood rearing, from whence no

further calling was heard (including during the second peak in calling at this site in July, see Fig. 2 in Fox *et al.* 2013).

These lines of evidence suggest that at least some of the birds at this site were single brooded at Lille Vildmose, remained on the territory which they had defended in the early phase after arrival to raise young, and did not take part in the second period of territorial advertisement in July 2013. Although we cannot prove this to be the case, the presence of new birds calling in previously unoccupied areas during July suggests new immigrants into the area. This raises the intriguing prospect as to whether this second wave of Spotted Crakes calling in July (and which are thought also to breed, because newly hatched young continue to be seen at Vejlerne well into August; Kjeldsen 2008) are new arrivals coming from areas further south and east within the breeding range having attempted to nest elsewhere, as is suspected to occur amongst Quail *Corturnix coturnix* (Guyomarc'h *et al.* 1998). This seems a likely possibility, given the apparent need of the species for stable shallow water with dense emergent vegetation in which to breed (Mallord 1999; Mackenzie 2000; Fox *et al.* 2013). Unless spring-fed to maintain water tables, the type of shallow water wetland vegetation favoured by the species (Schäffer 1999) is the very type of wetland habitat most likely to dry out, especially in the warm and semi-arid areas of North Africa, and of southern and eastern Europe where this species also breeds. Hence, it is not impossible to conceive of Spotted Crakes attempting and potentially succeeding in breeding in the south and east of the nesting range and individuals continuing north to attempt a second clutch in areas such as Denmark. The variable nature of the climate in the south may also account for the very large differences in numbers occurring here between years, although there was no clear correlation between the calibrated numbers entered into DOFbasen and spring/summer temperatures or hydrological drought condition in southern Europe in year *n* or *n*–1 (using data from Kavalieratou *et al.* 2012 for Greece; Sinoga & Gross 2012 for Spain) or precipitation in Poland (unpublished data). Kjeldsen (2008) also found no correlation between June temperature in Denmark and abundance at Vejlerne. Nevertheless the species is known to move locally during the breeding season in relation to local drying of groundwater conditions (Fox *et al.* 2013) and in extreme cases abandon others due to loss of shallow water (Schäffer 1999), which could provide an explanation for the arrival of a second wave of birds in July still with time to establish territories, pair and raise young before the autumn (Kjeldsen 2008). It would be interesting to see if the second wave appears in the avian observation portals of neighbouring countries such as the UK and Sweden.

It is intriguing that numbers of reported Corncrake and Quail reported to DOFbasen show highly variable abundance indices, with conspciuous influxes of Corncrake in 2000, 2002, 2003 and 2007, and of Quail in 2000–2003, 2006–8 inclusive, 2010 and 2011, and that their annual abundance indices are highly correlated with those of Spotted Crake. Whilst this could reflect suitability of settling and breeding conditions in Denmark or some factor (such

as weather conditions) that makes one or other set of birds in these peaks more detectable to observers in those years, we favour the hypothesis that conditions elsewhere in the range of these species result in greater numbers moving to Denmark. To find further support for the latter hypothesis, we recommend that radio-tracking of Spotted Crakes in both peaks continue in order to further understand the movements, habitat use and nesting phenology of individuals associated with both waves. We also suggest that a combination of radio telemetry and high quality sound recording should be implemented to determine the ability to detect individual birds from their calls (as has been demonstrated for Corncrake; Peake *et al.* 1998; Peake & McGregor 2001). This would further confirm the contributions of individuals to the two peaks in calling as well as potentially test for differences in dialect between birds calling in the two periods if they are geographically separated in most years (again as has been demonstrated for Corncrake; Peake & McGregor 1999; Mikkelsen *et al.* 2013). These approaches could usefully be supported by genetic and stable isotope analysis using tissues from birds calling in both periods to attempt to assess any genetic separation or evidence of using different habitats in spring that could contribute to a better understanding of this perplexing phenomenon. The ability to track year on year changes in abundance locally and nationally is dependent on understanding how calling birds relate to potentially breeding individuals. It is therefore important that we understand the birds' movements in order to avoid double-counting, by attempting to differentiate origins and individuals amongst calling birds at a site.

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Photograph: Spotted crake fitted with a metal ring, geolocator and radio antenna at Lille Vildmose, Denmark on 15 May 2014, by Mark Desholm.

